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A Survey of Emissions of Nitrogen Oxides in the Pulp Mill

Increasing man-made production of nitrogen oxides has demanded the attention of both scientists and regulatory officers. The Chattanooga community exposure study (1) has made it possible to ascertain a value for yearly average concentrations of nitrogen dioxide related to human health effects. The findings of the study made possible, less than 1 year later, the publication of air quality criteria for nitrogen oxide (NO_x). The promulgation in April 1971, of ambient air quality standards for NO_x reflected the considerations for margins of safety recommended in the criteria.

The man-made production of NO_x is only 10% of the total global production but practically half of the world man-made production originates in the United States. Detailed analysis reveals that 50% of United States man-made NO_x production is generated from stationary sources. Although specific industrial processes contribute less than 1% to the nationwide estimates, we decided in 1970 to conduct a preliminary survey of our typical combustion installations. Previously, Galeano *et al.* (2) showed that extremely low values of NO_x are obtained in the recovery furnace.

The present survey covered two neutral sulfite semichemical mills and an unbleached kraft mill, all with typical recovery furnaces. Also surveyed were two gas-fired power boilers; two combination bark boilers, one on coal and the other on gas; three coal-fired power boilers; a lime kiln and a sulfur burner.

Analytical and Sampling Methods

The phenoldisulfonic acid (PDSA) method was tentatively selected as the analytical method to be used. A survey

Abstract: A study was made of the amount and characteristics of nitrogen oxide emissions from typical pulp mill installations such as recovery furnaces, lime kiln, sulfiting tower, bark boilers, etc. A careful selection of the analytical method and procedure was undertaken to avoid interferences of sulfur compounds and particulates. Operating conditions, including temperature, residence time and air input characteristics, were closely watched. The scrubbing effect of certain conventional units such as venturi evaporators, and packed towers is not significant in reducing the concentration of NO_x. The authors concluded that the emissions of NO_x from a pulping and recovery operation are well below those of other combustion equipment and their effect on ambient air levels negligible.

Keywords: Nitrogen oxides · recovery furnaces · Spectrochemical analysis · Colorimetry · NSSC pulping · Kraft pulping · Air pollution · Industrial wastes · Exhaust gas · Surveys · Sampling

of the literature and additional information allowed us to develop a method compatible with future analytical requirements. Since sulfur dioxide interference with the PDSA method had previously been fully studied, we studied only the possible interference of reduced sulfur compounds on the method. We also investigated the effect of particulates as a color absorber in the colorimetric PDSA analytical procedure. These laboratory studies revealed no significant interference in either instance.

Analytical

The PDSA method is a colorimetric method in which the sample is absorbed in a hydrogen peroxide solution 0.1N in sulfuric acid. The resulting nitric acid is reacted with PDSA, and the yellow ammonium salt of nitrophenoldisulfonic acid is determined spectrophotometrically. A calibration curve is run using known concentrations of KNO₃ solutions.

The PDSA analysis procedure is laborious but not difficult. It involves a boil-down step which takes a few hours, with care needed to prevent splattering and charring of the product if left on the hotplate for too long. After the addition of PDSA, trituration, water and NH₄OH addition for color formation, the samples are diluted to 50 ml and absorbance is measured on a Spectronic 20 spectrometer at 420 nm. A calibration curve gives the amount of NO₂ at different readings.

Sampling

We selected a sampling method which would not only give accurate readings, but also would be practical to use at the stacks. The apparatus was the one used by NAPCA (National Air Pollution Control Agency) (3), which differs slightly from the one specified as Method No. 7 in the Federal Register of December 1971. The sample flask was a 250 ml cylindrical flask with glass stopcocks on each end. To grab a sample, 25 ml of absorbing solution (H₂O₂ on 0.1N H₂SO₄) was placed in the flask. The flask was then evacuated to 700-720 mm Hg, as determined by an open ended mercury manometer. Immediately after flask evacuation, the flask was connected to the sampling apparatus in the stack and the sample collected by opening a stopcock to the sampling probe.

The sampling apparatus may vary according to stack conditions. If the stack is under pressure, all that is needed is to run a line with a tee in it from the glass-lined stainless steel probe placed in the stack. The glass-lined probe was used because it has been reported (4) that oxides of nitrogen can be catalytically decomposed or reduced by carbon monoxide in hot stainless steel sampling equipment. The sample flask was connected to the tee to prevent the flask from being under pressure after taking the sample. Figure 1 schematically illustrates the sampling setup. When the stack was under vacuum, a vacuum pump was used to pull the sample. A bleed system after the sampling tee was used to

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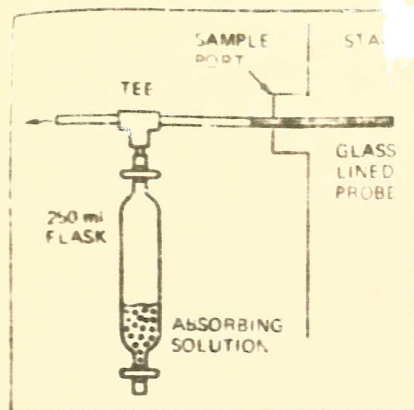


Fig. 1. Sampling apparatus, positive pressure in stack.

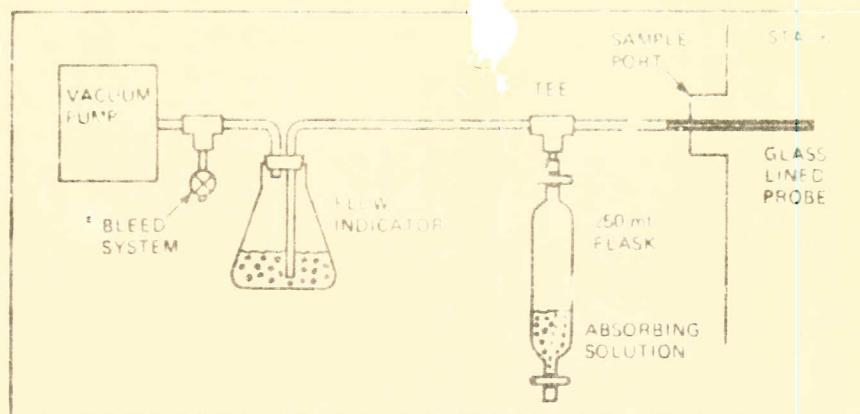


Fig. 2. Sampling apparatus, negative pressure in stack.

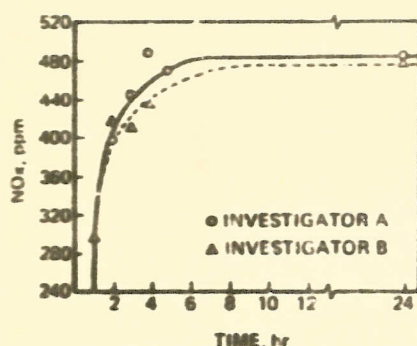


Fig. 3. Absorption rates.

prevent a vacuum from being created in the sample flask by the vacuum pump. Figure 2 is a schematic of the sampling setup under negative pressure conditions.

These precautions were necessary in order to make proper volume determinations. Volume was calculated from the initial volume of the flask, the pressure in the flask before sampling, the pressure in the flask after absorption, and the ambient temperature after absorption.

After the sample was taken at the stack, it was shaken for several minutes and then left sitting for about 16-24 hr so that total absorption could occur. That this time period was sufficient was shown by a study made by two investigators (5), working independently in the same laboratory setup and with the same described procedure. Figure 3 shows that for the maximum concentration studied, 500 ppm, final absorption occurred after 9 hr. No variation

was noticed after more prolonged absorption periods. The Environmental Protection Agency recommends, in the previously mentioned Method 7, an absorption period of no less than 16 hr. This was the period of time we used.

Temperature Determinations

All temperature measurements were made with a Leeds and Northrup optical pyrometer, measuring the hottest temperatures at the combustion zone.

SURVEY RESULTS

The results from the survey are indicated in Tables I-III. It is clear that emissions from typical combustion units in the pulping operation such as the kraft recovery furnaces, combination bark boilers, lime kilns, and sulfur burners are very low.

The kraft recovery furnace pattern is to be expected when considering the relatively low temperatures and the two-stage air feeding systems. The conventional kraft recovery furnace, in order to promote formation of sulfide, uses, in essence, the off-stoichiometric method of reducing nitric oxide formation so much in development today for gas-fired utility boilers. The two bark

Table I. Nitrogen Oxide Emissions From Neutral Sulfite Semichemical Mill A

Unit	NO _x		Combustion temp., °F
	Range, ppm	Average, ppm	
Power boilers			
Pulverized coal-front fired 100,000 lb/hr	310-445	375	2600-2700
Pulverized coal & bark 70,000 lb/hr	150-280	206	2200-2600
Smelter, black liquor			2000
Before venturi evaporator	45-120	73	
After venturi evaporator	65-90	79	
Sulfur burner			
Before sulfitation tower	25	25	
After sulfitation tower	10-20	15	

Table II. Nitrogen Oxide Emissions From Neutral Sulfite Semichemical Mill B

Unit	NO _x		Excess air	Combustion temp., °F
	Range, ppm	Average, ppm		
Power boiler, gas-fired, 100,000 lb/hr	325-535	436	33	
Recovery boiler	13-65	35	51	2050-2300

Table III. Nitrogen Oxide Emissions From Kraft Mill C

Unit	NO _x		Excess air	Combustion temp., °F
	Range, ppm	Average, ppm		
Recovery boiler, black liquor, 256,000 lb/hr	0-53	32	103	1850-2250
Power boiler gas-fired, 220,000 lb/hr	161-232	190	46	1600-1800
Power boiler, bark, 270,000 lb/hr	101-145	123	89	1900-2000
Lime kiln, 256 tons/day			23	2300-2500
Simultaneous sampling				
Inlet of scrubber	157-213	186		
Outlet of scrubber	113-260	200		

boilers, although burning mainly solid waste fuel, indicated lower temperatures than those normal for similar units either totally on gas or coal. The fact that the bark was being fed at a moisture content of 45 to 55% could be a reason for the lower NOx concentration.

The conventional power boiler units show results similar to those published by others (6, 7).

It was also found that neither a venturi evaporator nor a sulfitation tower had any significant effect on nitrogen oxide concentration. Specific studies at one installation on the effect of an electrostatic precipitator showed that the NOx concentrations were the same before and after the precipitator. Our results seem to indicate that the electrostatic precipitator is not a source of NOx emission, as has been implied in other publications.

CONCLUSIONS

1. The NOx emissions from unit operations typical of the pulping industry, other than power boilers, are well below comparable combustion units.

2. The contribution to ambient levels of NOx from a pulping operation would be of negligible effect on air quality.

3. Small size power boilers present emission characteristics of the same order as similar conventional power generating units.

4. There seems to be no need of continuous monitoring for NOx on the combustion units of pulping operation.

LITERATURE CITED

1. Shy, C. M., Cresson, J. P., Peariman, M., McClain, K. E., Benson, F., and Young, M. M., *J. Air Pollution Control Assoc.* 20 (8): 839 (1970).
2. Gakano, S. F., Kahn, D. C., and Mack, R. A., *Tappi* 45 (5): 741 (1971).
3. Personal correspondence with James Dorsey, National Air Pollution Control Agency (NAPCA), Cincinnati, Ohio (1970).
4. "Oxides of Nitrogen: Their Occurrence and Measurement in Flue Gas from Large Coal-Fired Boilers", *Brit. Coal Util. Res. Assoc. Monthly Bull.* 34 (10): 252 (1970).
5. Leopold, K. M. and Santelli, T. R., "NOx Absorption Study", Owens-Illinois, Inc., Unpublished report, October 6, 1971.
6. Cuffie, S. T. and Gerstle, R. W., "Emissions from Coal-Fired Power Plants: A Comprehensive Survey", Public Health Service Publication No. 999-AP-35, 1967, p. 15.
7. Walsh, R. T., "Boilers, Heaters, and Steam Generators", Air Pollution Engineering Manual, Public Health Service Publication No. 999-AP-40, 1967, p. 557.

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HYDROCARBON EMISSIONS FROM WOOD FIRED BOILERS

P. B. Bosserman
State of Oregon Department of Environmental Quality

Abstract

The current EPA emission factor is 2 to 70 lb HC/ton Fuel for Hydrocarbon (HC) emissions from wood and bark fired boilers. The author averaged available tests of wood fired boilers in Oregon to derive a new emission factor of 0.22 to 8.46 lb HC/ton Fuel with an average factor of 1.94. The results are broken down into four types of boilers: Dutch ovens, spreader stokers, fuel cells, and sanderdust fired. Reasons for some of the extreme values are discussed.

The Condensible Hydrocarbon caught in the back half of the total particulate train averaged 3.7% of the total particulate. Volatile Hydrocarbon weight averaged about seven times the Condensible.

Key Words

Hydrocarbon Emissions
Volatile Hydrocarbons
Condensible Hydrocarbons

Note on Author

Peter B. Bosserman, 44, does project reviews and devises improved control strategies for the Air Quality Division of the State of Oregon's Department of Environmental Quality located at 522 S. W. Fifth, Portland, Oregon 97204 (after December 1977). Bosserman is a 1959 graduate of Seattle University School of Mechanical Engineering. He is a registered engineer in Washington and Oregon. Bosserman formerly worked at Puget Sound Air Pollution Control Agency, Arthur Forsyth Company, and the Boeing Company.

Acknowledgments

The author is indebted to Miss Sheila Weitz for typing the text and data pages through three revisions. The author appreciates the encouragement and suggestions from his supervisors John F. Kowalczyk and H. M. "Pat" Patterson. Helpful review and testing came from Spencer L. Erickson, Patrick L. Hanrahan, and William D. Hartford of the Department's staff. Appreciation is also extended to the ten other testing teams who gathered most of the data on Condensible Hydrocarbons.

This paper was presented November 15, 1977 at the Air Pollution Control Association's Pacific Northwest International Section's annual meeting in Spokane, Washington.

HC

HYDROCARBON EMISSIONS FROM WOOD FIRED BOILERS

Present Emission Factors

The present emission factors for hydrocarbon (HC) pollutants emitted from wood and bark waste combustion in boilers, given by the United States Environmental Protection Agency (EPA) in AP-42, Table 1.6-1, is 2 to 70 lb HC/ton of fuel (1 to 35 Kg/MT). A footnote says to "use lower values for well designed and operated boilers". It is based on limited data published from 1967 to 1973. Since then, there have been many adjustments made to improve boiler combustion; fuel costs have gone up and pollution control agencies have demanded less pollution. At least one manual on improved combustion has been published, Dr. Junge's bulletin¹.

In 1976, the State of Oregon's Department of Environmental Quality (referred to as the Department hereinafter) started to analyze wood fired boilers' HC emissions in the Medford Air Quality Maintenance Area. Violations of the 160 $\mu\text{g}/\text{m}^3$ photochemical oxidant standard were occurring (along with violations of the particulate ambient air standard). The Department's emission inventory showed that the area's seventeen wood fired boilers were emitting 473 tons/year of the area's 8,529 tons/year of HC from controllable sources. Yet the 473 tons/year was based on the educated guess that the correct emission factor was 2 lb/ton based on the lower limit of EPA's published factor.

Oregon Test Program

The Department decided to verify the HC emission factor of 2 lb HC/ton of fuel by existing test data supplemented by additional tests. HC can be considered by arbitrary definition in two parts:

1. Volatile HC - Those with a high vapor pressure, i.e., alpha pinene. These will mostly evaporate during analysis if captured by a Method V train³ (see Page 7 for test method).
2. Condensable HC - Those with low vapor pressure, i.e., abietic acid. These tars will mostly be captured in the back half of a Method V train³ (see Page 7 for test method).

The Department had tests on twelve of the seventeen Medford area boilers which quantified the Condensable HC. The five not measured were small boilers or had not been measured because of similarity to another boiler beside them which had been measured. See the boilers 15-0010-1 through 15-0058-1 on Pages 17 and 18.

To this existing data, the Department had to add Volatile HC measurements. The Department began to measure Volatile HC emissions from wood fired boilers and veneer dryers in November 1976. Since alpha and beta pinene were known to be major constituents, at first only these HC were measured. They both have molecular weights of 136.24 and were found to be emitted at from .026 to 2.84 lb of pinenes per ton of fuel burned in the four boilers measured.

Beginning with the February 15, 1977 test, total nonmethane HC emissions were measured in the nine tests shown on the Volatile HC Data Page, Page 12. Most of the larger Medford area boilers were sampled; the test on 15-0054-2 was aborted because of a test equipment failure; 15-0048-1 was not measured because it is exactly like 15-0048-2.

The results of the Oregon Test Program and of this paper show that the 2 lb/ton emission factor was a good educated guess, close to the Medford boilers and the averages developed in this paper.

The test results are as follows:

TABLE 1
Wood Fired Boiler HC Emissions

	Number of Tests	Emission Factor Units					
		1b HC/Ton Fuel			1b HC/10 ⁶ 1b Steam		
		Average	High	Low	Average	High	Low
Volatile HC	9	1.68	6.30	.22	190	745	31
Condensible HC	88	.26	2.16	negl	23	256	0.1
Total HC		1.94	8.46	.22	213	1,001	31

The author separated the measurements into four types of wood fired boilers. Descriptions and illustrations of these types were presented in the author's paper⁶ at last year's meeting.

TABLE 2
HC Emissions by Type of Wood Fired Boiler

	Number of Tests	Emission Factor Units					
		1b HC/Ton Fuel			1b HC/10 ⁶ 1b Steam		
		Average	High	Low	Average	High	Low
Dutch Ovens							
Volatile HC	4	.54	1.03	.22	114	200	31
Condensible HC	50	.23	2.16	negl	22	105	negl
Total HC		.77	3.19	.22	136	305	31
Spreader Stokers							
Volatile HC	3	3.84	6.31	2.00	388	745	119
Condensible HC	26	.33	2.08	.01	35	256	1
Total HC		4.17	8.39	2.01	423	1,001	120
Fuel Cells							
Volatile HC	1	.43	.43	.43	42	42*	42
Condensible HC	5	.31	.86	.01	14	33*	4
Total HC		.74	1.29	.44	56	75*	46
Sanderdust Only							
Volatile HC	1	1.03	1.03	1.03	45	45	45
Condensible HC	7	.41	1.02	.11	8	23	1
Total HC		1.44	2.05	1.14	53	68	46

*Same Boiler

Volatile HC

Volatile HC emissions from veneer dryers were studied in 1971 by Washington State University². Since no identification of constituents of HC emissions from wood fired boilers has been done, except for the Department's four tests mentioned on Page 2, it is assumed that the compounds in wood fired boiler emissions will be similar, if not the same as, compounds in veneer dryer emissions. Constituents in Volatile HC are alpha pinene, beta pinene, etc.

The Department is of the opinion that these Volatile HC are as photochemically reactive as the most reactive class of compounds listed by EPA⁵. The Department's method for collecting and analyzing the Volatile HC is detailed in Appendix I. Briefly, an integrated bag sample was taken from a single point in a stack and analyzed on a gas chromatograph.

Condensible HC

Condensible HC emitted from wood fired boilers are captured and measured in the process of measuring total suspended particulate. The Department defines, "Particulate matter means any matter, except uncombined water, which exists as a liquid or solid at standard conditions". In the Department's emission inventory, these Condensible HC emissions are classified as particulate rather than hydrocarbons, but conceivably they could volatilize under certain atmospheric conditions; their photochemical reactivity has not been measured. From their chemical structure, they are suspected to be less reactive than gasoline but more reactive than acetone. See Appendix I for the test method.

The Condensible HC are pitches and tars which have greater molecular weights than the Volatile HC. Some of the constituents identified by Washington State University were abietic acid, isomers of abietic and pimaric acids, sesquiterpenes.

Discussion of Data

In order to establish an unbiased average, the author surveyed all the 300 wood fired boilers in Oregon. Only the latest test on each boiler was considered. Where the boiler was no longer in service, the test was not used. Finally, only 89 tests could be used to measure Condensible HC; in the other tests the back half, if reported, did not itemize the inorganic (water soluble) and the organic fractions. In summary, every wood fired boiler in service during August 1977 in Oregon was used to form the Condensible HC data, if the organic portion of the back half of the boiler's source test was reported.

The test results are presented in terms of two emission factors. The lb HC/ton fuel factor is direct and in terms common to other fuel factors. But wood waste is not measured carefully as with other fuels. More often than not, it is generated at the plant and burned without being measured or weighed. Over two-thirds of Oregon's wood fired boilers do have recording steam flow meters. So a second emission factor in terms of lb HC/10⁶ lb steam produced is presented. It is believed to be more accurate; however, mills do give the Department their estimate of the tons of wood burned in boilers annually, so the lb HC/ton fuel can be as easily derived.

The author extracted the percent CO₂ in the flue gas, the fuel moisture, the steaming rate in percent of rated steam capacity, and the stack temperature from each of the test runs in the 88 tests where Condensible HC was measured. By a linear regression analysis each of these parameters was correlated to each of the computed emission factors. The highest correlation coefficient was .797 for the stack temperature of fuel cell boilers with the lb HC/ton fuel coefficient. But where the slope of this correlation was positive, the other stack temperature correlations had negative slopes. Of the 32 correlations, only seven had correlation coefficients above .500. It is concluded that HC emissions have no dependence on any single parameter.

This agrees with combustion theory where combustion efficiency is dependent on time, turbulence, temperature, and correct Oxygen supply. If any of these parameters is incorrect, poor combustion with concurrent changes in emissions of HC will result. To cite a few instances, when a boiler is fired over rated capacity, the residence time in the fire zone is shortened; boiler 15-0053 was being fired at 100% rated capacity and produced HC several times the average. When too much combustion air is provided, the fire cools below the optimum combustion efficiency temperature. As indicated by low CO₂ flue gas readings, boilers 25-0005-1 at 7.6% CO₂ and 10-0021-1 at 6.03% CO₂ registered the highest Condensible HC emission factors for Dutch Ovens and Spreader Stokers probably because of low fire box temperatures.

Back Half of the Catch

There has been continuing difference of opinion on whether the back half of the Method V train should be included in the total suspended particulate measurement. Those who favor it being excluded consider it so small as to be negligible. Others, like the Department, want it measured, reported, and included because sometimes it is not negligible. Because I was tabulating back half data, I included the total back half (organic and inorganic) in my survey to determine the range of back half weight. See the back half columns in Appendix III on the Condensible HC Data Pages. From 89 tests:

Total particulate back half was 6.05% of the total particulate on the average.
The highest value was 26.6% for boiler 05-2064-1.
The lowest value was 0.34% for boiler 15-0048-3.
In ten of the 89 tests, the back half was over 12%.
Condensible HC averaged 3.707% of the total particulate.

Conclusions

1. The range of the EPA factor of 2 to 70 lb HC/ton of fuel appears too high and should be lowered to about 0.20 to 8.5 lb HC/ton of fuel. Values of 2.0 to 8.5 lb/ton should be used where tests confirm this or opacities are seen to exceed 20%. An average value of 2.0 lb HC/ton of fuel is indicated for boilers with good combustion and opacities of 20% or less in the absence of actual measurements or other facts. Values of 8.5 to 70 lb HC/ton of fuel may be realistic where high opacity and poor combustion practices are observed.

measured. Those who favor it being excluded consider it to be negligible. For example, like the Department, want it measured, reported, and included in the report. It is not negligible because it is a significant back half data, I included the total back half (volatile and condensable) in the Method V train should be measured and included in the weight report. Sometimes it is over 12% of the total.

Total particulate back half was 6.05% of the total

3. Volatile HC weight averaged about seven times the Condensable HC.

The highest value was 26.6% for boiler 05 2064-1.

4. Spreader Stoker type wood fired boilers have higher HC emission rates than other types. In 39 tests, the back half was over 12%.

Condensable HC averaged 3.707% of the total particulate

5. There is no one key parameter to lower HC emissions except overall better combustion.

1. The range of back half factor of 2 to 70 lb HC/ton of fuel appears to be reasonable. The average is about 0.20 to 3.7% lb HC/ton of fuel. The range of 2 to 70 lb HC/ton of fuel may be realistic where high opacity and poor combustion practices are observed.



AIR POLLUTION CONTROL DISTRICT
COUNTY OF HUMBOLDT

5600 SOUTH BROADWAY EUREKA, CALIFORNIA 95501

PHONE (707) 443-3091

March 4, 1980

Mr. Clyde B. Eller, Director
Enforcement Division
EPA, Region IX Office
215 Fremont Street
San Francisco, CA 94105

RE: E-4-4-1
NC 79-07

Dear Mr. Eller:

The Air Pollution Control Director of Mendocino County has asked us to review your February 1, 1980 letter to Mr. Ralph Shoulders of the Georgia-Pacific Corporation regarding approval for the construction of a 140,000 lb/hr wood-fired steam generator at Fort Bragg, CA. Page one of your letter contains emission rate information for several pollutants. The table below summarizes our calculations and compares them with your estimates based on limiting concentrations and reduced operating times.

TABLE 1

<u>POLLUTANTS</u>	LIMITING CONCENTRATION	EPA ESTIMATE (T/YR.)	NORTH COAST DIST. EST.	
			(T/Y)@70% CAP/310 Da.	(T/Y)@100% CAP/360 Da.
SO _x	0.01%	16.0	16	26
NO _x	120 ppm	131.0	156	259
Partic- ulates	0.03 gr/scf @ 12% CO ₂	46.9	47	78
CO	100 ppm	67.0	79	132
VOC	75 ppm	68.3	34	56

Our estimated emission rates for volatile organic compounds (VOC) are in disagreement. Attached to this letter are calculations which will substantiate our values.

Attached to your letter are permit conditions about which we have some concern. Section VIII F. requires that the emissions of volatile organic compounds be limited to 75 ppm (volume) @ 12% CO₂ as CH₄ (2-hr. ave.).

A limit of 75 ppm is a reasonable limit on VOC emissions in a well controlled furnace burning clean dry wood. When these conditions are not ideal and the fuel varies in composition and quality, sometimes hourly, emissions can double. If EPA had this in mind, and the 68 T/YR. emissions of hydrocarbons is correct then the limiting concentration should be 150 ppm.

Our goal is to reduce air polluting emissions. Tepee burners and open burning methods are still used to dispose of large quantities of waste wood in the North Coast Air Basin. The following table compares the emissions of VOC and particulates per ton of fuel burned by three methods.

TABLE 2

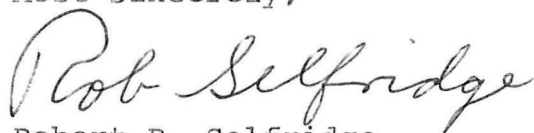
<u>METHOD OF BURNING</u>	<u>LB. VOC</u> <u>TON OF WOOD</u>	<u>LB. OF PARTICULATE</u> <u>TON OF WOOD</u>
Douglas fir in a large boiler	1.7	2
Douglas fir burned in open	5	8
Wood in a Tepee Burner	4	8

This data shows that we can approach our goal faster by encouraging industry to build large and efficient boilers to eliminate Tepee Burners and as oil becomes more valuable to burn slash from the forests and municipal wastes from the cities.

Regulations are needed but not long delays and "tough" restrictions.

As fuel becomes more valuable industry will have economic incentives to (1) provide dry storage and pre-dry the chips (2) pre-size the chips more carefully (3) study operating conditions for most efficient combustion. These steps will reduce pollutant emissions and optimize the use of an otherwise troublesome by-product.

Most Sincerely,



Robert R. Selfridge
Air Pollution Control Director

CC: R. Swan, Mendocino
Carolyn Stromberg, ARB

G.P., FORT BRAGG - #5 BOILERA. EMISSION RATES:1. Particulate: 0.03 gr/scf @ 12% CO₂At capacity, 140,000 lb/hr steam: ~70,000 scfm (12% CO₂)

$$\frac{0.03 \text{ gr/scf} \times 70,000 \text{ scfm} \times 60 \text{ min/hr}}{7000 \text{ gr/lb}} = 18 \text{ lb/hr}$$

$$@ 24 \text{ hr/day, } 360 \text{ d/yr.} = \underline{78 \text{ T/yr.}}$$

$$@ 7450 \text{ hr/yr.} = \underline{67 \text{ T/yr.}}$$

$$@ 70\%, 7450 \text{ hr/yr.} = \underline{47 \text{ T/yr.}}$$

2. Sulfur Oxides: 0.01% Sulfur in wood (dry)

At capacity, fuel use is 15 T/hr

$$0.0001 \times 30,000 \text{ lb/hr} = 3 \text{ lb/hr S}$$

$$= 6 \text{ lb/hr SO}_2$$

$$@ 24 \text{ hr/day, } 360 \text{ d/yr} = \underline{26 \text{ T/yr}}$$

$$@ 7450 \text{ hr/yr} = \underline{22 \text{ T/yr.}}$$

$$@ 70\%, 7450 \text{ hr/yr.} = \underline{16 \text{ T/yr.}}$$

3. Carbon Monoxide: 100 ppm @ 12% CO₂

At capacity,

$$\frac{100 \text{ ppm} \times 70,000 \text{ scfm} \times 28 \text{ lb/lb-mole} \times 60 \text{ min/hr}}{386 \text{ scf/lb-mole}} = 30.5 \text{ lb/hr}$$

$$@ 24 \text{ hr/day, } 360 \text{ d/yr} = \underline{132 \text{ T/yr.}}$$

$$@ 7450 \text{ hr/yr} = \underline{114 \text{ T/yr.}}$$

$$@ 70\%, 7450 \text{ hr/yr.} = \underline{79 \text{ T/yr.}}$$

4. Volatile Organic Compound (VOC): 75 ppm @ 12% CO₂ as CH₄

At capacity,

$$\frac{75 \text{ ppm} \times 70,000 \text{ scfm} \times 16 \text{ lb/lb-mole} \times 60 \text{ min/hr}}{386 \text{ scf/lb-mole}} = 13.0 \text{ lb/hr}$$

$$@ 24 \text{ hr/day, } 360 \text{ d/yr} = \underline{56 \text{ T/yr.}}$$

$$@ 7450 \text{ hr/yr.} = \underline{48 \text{ T/yr.}}$$

$$@ 70\%, 7450 \text{ hr/yr.} = \underline{34 \text{ T/yr.}}$$

5. Nitrogen Oxides: 120 ppm @ 12% CO₂ as NO₂

At capacity,

$$\frac{120 \text{ ppm} \times 70,000 \text{ scfm} \times 46 \text{ lb/lb-mole} \times 60 \text{ min/hr}}{386 \text{ scf/lb-mole}} = 60 \text{ lb/hr.}$$

$$@ 24 \text{ hr/day, } 360 \text{ d/yr.} = \underline{259 \text{ T/yr.}}$$

$$@ 7450 \text{ hr/yr.} = \underline{224 \text{ T/yr.}}$$

$$@ 70\%, 7450 \text{ hr/yr.} = \underline{156 \text{ T/yr.}}$$

B. EMISSION FACTOR ANALYSIS:

1. Volatile Organic Compounds (VOC)

From above emission rate of 13.1b/hr at 140,000 lb steam/hr:

$$= \frac{13 \text{ lb VOC/hr}}{140,000 \text{ lb steam/hr} \times 10^6} = \underline{93 \text{ lb VOC} / 10^6 \text{ lb steam}}$$

Factor
for 75 ppm
VOC

Comparison of factor derived from EPA limit with Oregon DEQ report (attached copy of factors).

(a) Average VOC (Oregon) = 190 lb VOC / 10^6 lb steam

(b) Spreader Stoker VOC (Oregon) = 388 lb VOC / 10^6 lb steam

CONCLUSION: The EPA limit of 75 ppm (93 lb VOC / 10^6 lb steam) is ~50% of the average factor and ~25% of the spreader stoker factor. The limit may not be met.

2. Oxides of Nitrogen (NO_x)

From above emission rate of 60 lb/hr at 140,000 lb/hr steam:

at 970 BTU/lb steam = 1.35×10^8 BTU/hr.

$$\therefore \frac{60 \text{ lb NO}_x/\text{hr}}{135.8 \times 10^6 \text{ BTU/hr}} = 0.44 \text{ lb NO}_x / 10^6 \text{ BTU}$$

Comparison of factor derived from EPA limit with EPA-600/7-79-219 September 1979 "NO_x Emission Factors for Wood-Fired Boilers" Interagency Energy/Environment R&D Program Report (attached copy).

(1) Factor for ≥ 10.0 MW Boilers = $0.16 \text{ lb} / 10^6 \text{ BTU}$

CONCLUSION: The EPA limit of 120 ppm NO_x is higher than that achieved by most wood-fired boilers based on the most recent data.

Beginning with the February 15, 1977 test, total nonmethane HC emissions were measured in the nine tests shown on the Volatile HC Data Page, Page 12. Most of the larger Medford area boilers were sampled; the test on 15-0054-2 was aborted because of a test equipment failure; 15-0048-1 was not measured because it is exactly like 15-0048-2.

The results of the Oregon Test Program and of this paper show that the 2 lb/ton emission factor was a good educated guess, close to the Medford boilers and the averages developed in this paper.

The test results are as follows:

TABLE 1
Wood Fired Boiler HC Emissions

	Number of Tests	Emission Factor Units			lb HC/10 ⁶ lb Steam		
		lb HC/Ton Fuel	Average High Low		Average	High	Low
-Volatile HC	9	1.68	6.30	.22	190	745	31
Condensible HC	88	.26	2.16	negl	23	256	0.1
Total HC		1.94	8.46	.22	213	1,001	31

The author separated the measurements into four types of wood fired boilers. Descriptions and illustrations of these types were presented in the author's paper⁶ at last year's meeting.

TABLE 2
HC Emissions by Type of Wood Fired Boiler

	Number of Tests	Emission Factor Units			lb HC/10 ⁶ lb Steam		
		lb HC/Ton Fuel	Average High Low		Average	High	Low
Dutch Ovens							
-Volatile HC	4	.54	1.03	.22	114	200	31
Condensible HC	150	.23	2.16	negl	22	105	negl
Total HC		.77	3.19	.22	136	305	31
Spreader Stokers							
-Volatile HC	3	3.84	6.31	2.00	388	745	119
Condensible HC	26	.33	2.08	.01	35	256	1
Total HC		4.17	8.39	2.01	423	1,001	120

Fuel Cells							
-Volatile HC	1	.43	.43	.43	42	42*	42
Condensible HC	5	.31	.86	.01	14	33*	4
Total HC		.74	1.29	.44	56	75*	46
Sanderdust Only							
-Volatile HC	1	1.03	1.03	1.03	45	45	45
Condensible HC	87	.41	1.02	.11	8	23	1
Total HC		1.44	2.05	1.14	53	68	46

*Same Boiler separated the measurements into four types of wood fired boilers. Descriptions and illustrations of these types were presented in the author's paper⁶ at last year's meeting.

Doing fir open burner
Wood in TP burner

5.0
4.0

TABLE 2

560
450

HC Emissions by Type of Wood Fired Boiler

Combustion Power Company, Inc.
A Weyerhaeuser Company



February 28, 1980

Mr. Wally Woo
EPA-Region 9
215 Fremont St.
San Francisco, CA 94105

Dear Sir:

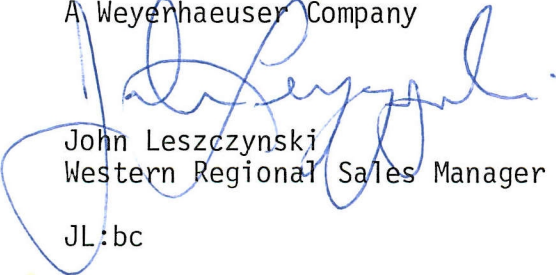
With the thought of keeping you up-to-date on the latest technology with regard to wood-fired boiler particulate emission control, I am enclosing the results of recent emissions tests performed on boiler #11 at Weherhaeuser's Mill in Longview, WA.

Our ELECTROSCRUBBERTM, electrostatic gravel media filter, allowed this boiler to operate at full capacity with a completely clear stack-- without the danger of fires and explosions and maintaining collection efficiency even during upset conditions(such as soot-blowing).

If you have any questions, please call me at your convenience.

Sincerely yours,

COMBUSTION POWER COMPANY
A Weyerhaeuser Company



John Leszczynski
Western Regional Sales Manager

JL:bc

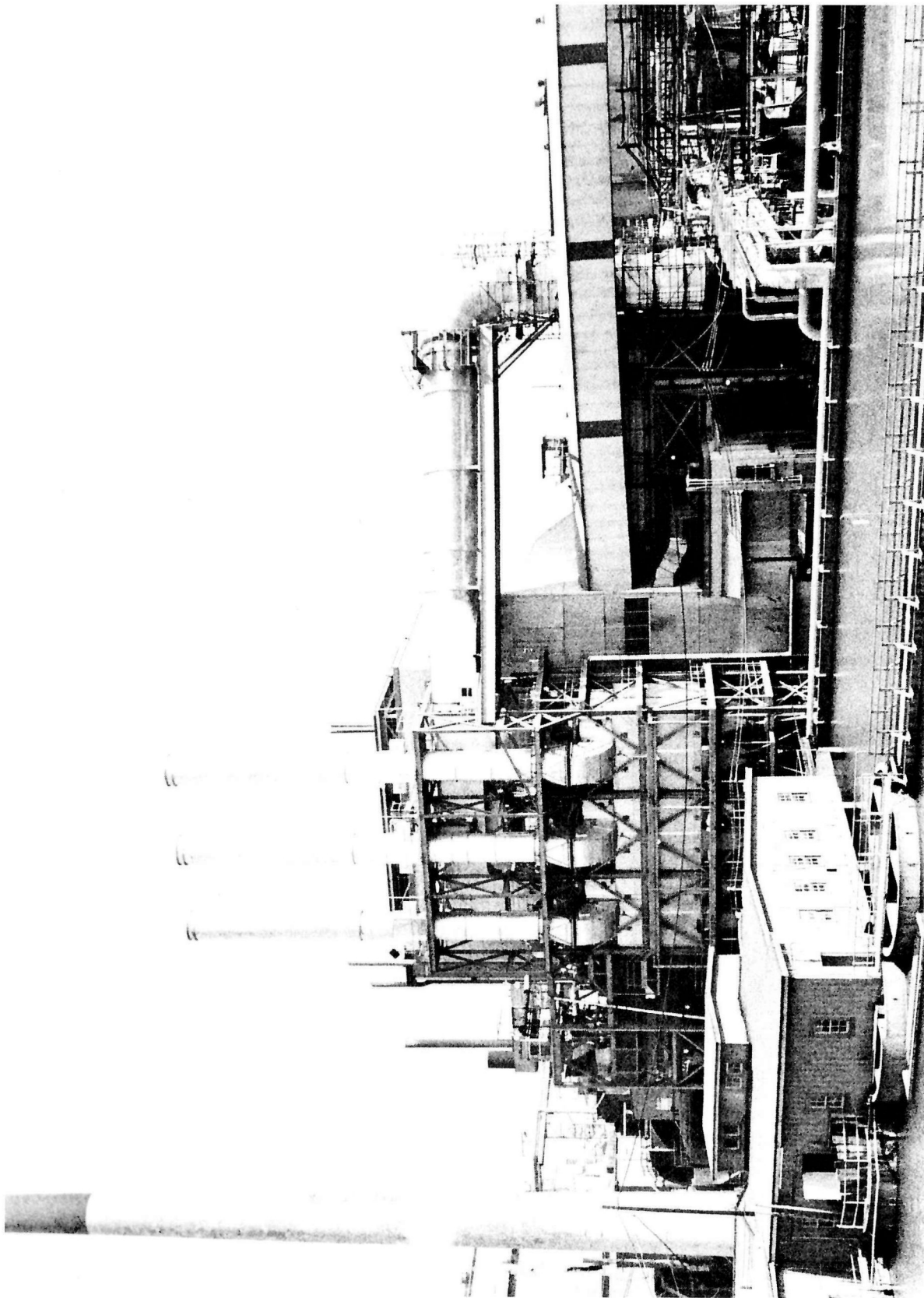
ELECTROSCRUBBER™ EMISSION TESTS
HOG FUEL BOILER #11 @ WEYERHAEUSER, LONGVIEW, WA.

TEST DATE	TEST NO. (AS #)	BOILER STEAM LOAD (Kpph)	HOG FUEL MOIST. (%)	INLET TEMP (F)	INLET GAS FLOW (ACFM)	TOTAL GRID POWER (kW)	ΔP in. (H ₂ O)	INLET PART. CONC. (gr/dscf)	OUTLET PART. CONC. (gr/dscf)
12/4/79	1 (1-M5)	350	53.3	345	236,299	2.8	3.2	0.193	0.009
12/6/79	2 (2-M5)	330	58.1	351	256,308	3.2	3.5	0.152	0.003
12/7/79	3 (3-M5)	343	55.3	351	274,792	0	3.0	0.142	0.022
12/7/79	4 (1-PS)	350	54.2	351	274,792	3.8	3.0	0.175	0.010
12/11/79	5 (2-PS)	350	56.9	370	290,000	3.0	4.0	0.535	0.012
12/11/79	6 (3-PS)	410	55.4	388	342,734	3.6	5.1	0.428	0.005
12/11/79	7 (4-M5)	390	53.8	388	342,734	3.5	5.1	0.174	0.011

NOTES:

1. This data was collected using an EPA Method 5 (M5) and Cascade Impactor (PS) test procedure.
2. Boiler nameplate capacity at 55% moisture hog fuel is 400,000 pph steam at 1250 psig.
3. All inlet and outlet loadings were corrected to 12% CO₂.
4. Grid voltage was 20,000 volts (except for test number 3 where it was purposely set at 0). Opacities ranged from 2%–3%, test number 3 produced an opacity of 5%.
5. Particulate sampling was done by Alsid, Snowden and Associates, Bellevue, WA. Operating data for the boiler and ELECTROSCRUBBER were collected by C. T. Main, Portland, OR.





3 MODEL ES 250-4 ELECTROSCRUBBERS™
WEYERHAEUSER COMPANY, LONGVIEW, WASHINGTON
HOG FUEL BOILER NO. 11



Combustion Power Company, Inc.
A Weyerhaeuser Company

JOHN LESZCZYNSKI

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